



# UNLOCKING THE LNG fuel **supply chain**

**L**NG as a fuel is a growing market that is driven by regulatory, environmental and economic factors. The stricter emission standard for SO<sub>x</sub> imposed by the International Maritime Organization (IMO) since 1 January 2015 and the forthcoming regulation for NO<sub>x</sub> emissions will impose either a move to cleaner fuel or the installation of scrubbers.

Although low natural gas prices position LNG as an affordable fuel, the cost of distribution could cancel out this economic advantage. Whereas the supply chain for conventional fuel is well established and usually well amortised, LNG distribution is subject to significant investment. A less costly LNG fuel supply chain is necessary to decrease the price of LNG delivered on board so that it remains competitive.

**Guillaume Gelin, Gaztransport & Technigaz (GTT), France,** discusses the safe and economic transfer of LNG from a bunker vessel to an LNG-fuelled ship.

Since the quantity of LNG at play during bunkering operations remains low, bunkering from trucks has been preferred. The drawbacks associated with truck-to-ship bunkering, such as the number of trucks and extended load time, are counterbalanced by low investment requirements. Nevertheless, a bunker barge or a vessel will be required before considering a larger LNG-fuelled ship.

Therefore, the ship-to-ship (STS) LNG transfer solution is a key element of the supply chain of LNG as a fuel. Although similar systems already exist in the offshore industry, they appear to be quite complicated, costly and unsuitable for bunkering.

Gaztransport & Technigaz (GTT) decided to develop a simple and safe LNG bunker mast inspired by the existing bunkering system for conventional fuel. This bunker mast has been designed in order to remain as competitive as possible without any compromise on safety.

## Capabilities

With a 20 m boom length, the mast is able to bunker most of the ships independently from a specific bunker station arrangement. The working envelope is as follows:

- ▶ Working radius: 20 m.
- ▶ Luffing range: 0°/60°.
- ▶ Luffing speed: 1 rad./min.
- ▶ Slewing speed: 0 – 0.7 RPM.



**Figure 1.** Reach4® loading container ship.



**Figure 2.** Reach4 – GTT LNG bunker mast.

- ▶ Slewing range: -170° – +170°.

The bunkering operation can be carried out in a sheltered area, such as a harbour or waiting zone at anchorage.

## Not a new concept

The bunker mast concept is used every day to bunker thousands of vessels around the world. It has become a standard practice for conventional fuel. GTT has simply taken this well proven system and adapted it to LNG constraints. For instance, pipes are now suitable for cryogenic conditions and the structure has been reinforced. The key to this new product is the simple and stand-alone emergency disconnect system.

## Emergency disconnect system

As required by ISO TS 18683, the transfer system should be capable of being disconnected rapidly in order to minimise damage in case of the ship drifting. Either a powered emergency release coupling (traditionally used in the offshore industry) or a breakaway coupling (preferred for bunkering applications) can be used.

Reach4® is fitted with breakaway couplings allowing an emergency disconnection in case of excessive stress on the flexible hoses. These components are based on breaking studs and non-return valves in order to isolate the hose inside from air in case of disconnect.

In order to prevent hose damage during emergency disconnect, a hose-brake ensures that the hose falls at a constant velocity in all situations. This subcomponent is based on a hydraulic pump and a constant flow valve. As such, it does not require any power.

The emergency disconnect system is inherently safe. The system remains operational, even in the event of total black-out. Whereas a powered emergency release coupling requires a complex system to monitor the relative position of ships and a compressed air tank to trigger disconnection in the event of loss of power, the breakaway coupling and hose brake are stand-alone and operational whatever the situation.

Furthermore, thanks to an innovative design, the breakaway coupling can be installed on the bunker mast itself, rather than hanging outside. Indeed, this safety device is generally fitted on the middle of the flexible hose in order to prevent the bending moment, which could lead to random disconnect. The Reach4 hose-guide ensures that the forces on the breakaway coupling always act in an axial direction.

The current breakaway coupling does not allow a manual trigger, but it is clear that a passive disconnect system remains not only more simple and reliable, but also more adapted to LNG bunkering than an active system. However, it is possible to add an active functionality to a breakaway coupling, which would result in a passive and active disconnect device. Although this new



functionality would not be very useful in a classical configuration, such as STS, it could allow the mast hose to be connected directly to a truck, for example.

## Operations

The mast is designed to perform LNG loading at 600 m<sup>3</sup>/hr with a 6 in. liquid line and a 4 in. vapour return line. However, larger pipe diameters can be provided to accommodate larger flow rates. The mast is also designed to perform all the commissioning and decommissioning operations of client vessel tanks. Thus, the bunker vessel will be able to perform drying, gassing up, cooling down, warming up, inerting and aerating of those tanks.

Last, but not least, it can also be used for bunker vessel loading or customer tank discharging.

Valves located just before the flexible hoses allow precooling before deployment and connection to the customer ship, as well as post inerting after disconnect. This significantly decreases the connection and disconnect time. Consequently, the immobilisation time of the client's vessel is reduced.

These valves are also used as emergency shut down (ESD) valves. Consequently, the inventory between the ESD valves of the bunker vessel and the ESD valves of the customer vessel is kept to a minimum. Therefore, the LNG release to be considered for the gas dispersion study is significantly reduced.

## Design

Currently, there are not any strict design rules for an LNG bunkering system. As such, several standards and guidelines have been used to validate the methodology. The design criteria, basic loads, load combinations and safety coefficients are based on codes such as:

- ▶ ISO 18683 for minimum functional requirements.
- ▶ EN 1474-3 for safety coefficient and functional requirements.
- ▶ API RP 2A for lattice structure design.
- ▶ BV NR526 for dynamic amplification factor and design of pedestal.

It can be noted that this methodology has been submitted to Bureau Veritas in the framework of an Approval in Principle.

For example, a conservative value for a dynamic amplification factor of 1,55 has been considered. This value covers most of the cases, eliminating the need for specific motion studies.

The mast is also designed to sustain the breaking loads of the breakaway coupling, whatever the direction of application of the pull force in the hose. This breaking load takes into account the maximum pulling force during operation (in order to prevent random disconnect), as well as tensile load due to pressure in the pipe.

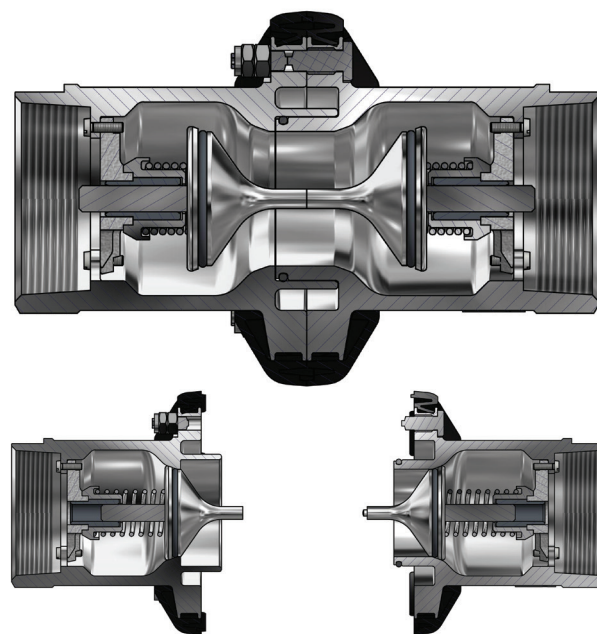
$$SP_{BaC} > 1.3 * T_{max} + P_{max} * S$$

Where:

- ▶  $SP_{BaC}$  = breakaway coupling breaking load.
- ▶  $T_{max}$  = maximum pulling force in operation considering hoses full of LNG and covered with ice, as well as maximum acceleration in operation.
- ▶  $P_{max}$  = maximum operating pressure in pipe.
- ▶  $S$  = pipe section.



**Figure 3.** Existing bunker mast for conventional fuel.



**Figure 4.** Breakaway coupling principle (courtesy of Manntek).



**Figure 5.** 400 m<sup>3</sup> bunker vessel with Reach4.

## Reliable

Whereas rigid arms require multiple swivel joints (a minimum of seven per line) to accept six degrees of freedom, the bunker mast uses only one of these leak-prone components. The swivel joint is fitted inside the slewing column with easy access. Moreover, a gas detector inside the slewing column can detect any leakage of this critical component.

The lattice structure allows easy access to every component requiring maintenance (e.g. valve, hose brake and breakaway coupling).

## Procedure

Reach4 is very similar to the existing bunker mast for conventional fuel. As such, the bunker procedure will be almost the same. Therefore, operators will be familiar with Reach4 and the associated procedures. Moreover, the integration of a breakaway coupling on the mast is self-explanatory during transfer, normal connection and normal disconnect operation.

## Application

Although the current design is sized according to given operational range and flow rate, it can be easily adapted to other specifications. Reach4 will, therefore, be suitable for a large range of applications, such as a

bunker vessel or bunker barge. GTT's new LNG bunker mast will see its first application on a 2200 m<sup>3</sup> LNG bunker barge currently under construction in the US.

## Conclusion

The combination of breakaway couplings, lattice structure and bunker mast concept makes a simple and economic transfer system for LNG bunkering operations feasible. The bunker mast concept has already proven itself in the bunkering industry for conventional fuel and is about to unlock the development of the LNG fuel supply chain. **LNG**